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Research Article

Nanoligament Combined with Tennis Exercise on Rehabilitation Training for Treatment of Ligament Injury Patients

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This article mainly studies the effect of nanoligament combined with tennis on the rehabilitation of ligament injury patients. This article first uses nanoligaments made by ACL reconstruction technology to give targeted rehabilitation treatment to patients with ligament injuries, analyzes the internal structure of the knee joint cavity ligaments, and clarifies the rehabilitation of ACL injuries and other combined injuries. The construction method of nanoligament composite fiber composite ligament is mainly introduced. Secondly, the nanoligament damage mechanism can be used to prevent excessive knee deformation and internal rotation. Finally, the nanoligament is combined with the fiber composite ligament, and the silk fibroin filament yarn is used as the axis to form a composite structure on the fiber composite ligament structure to strengthen the rehabilitation effect for patients with ligament injury. In this study, combined with the data analysis of patients with nanoligament injury, it was found that after 50 patients have undergone corresponding tennis training and knee flexion angle observation, the recovery speed is 5 times faster than that of ordinary patients. The experimental results show that the combination of nanoligaments and tennis has a positive effect on rehabilitation training for patients with ligament injury.

1. Introduction

1.1. Background and Significance. Anterior cruciate ligament (ACL) injury is a common serious sports injury. The anterior cruciate ligament has the important function of restricting the excessive advancement of the hard bone and controlling the rotation. Knee joint instability occurs after the anterior cruciate ligament is damaged. Since then, meniscus cartilage injury, articular cartilage injury, and knee arthritis symptoms are treated. Treatment is a hot spot in the field of sports medicine. About 3.5 million anterior cruciate ligaments are damaged in the United States each year, and the annual medical cost is $6.5 billion. With the development of China's national strength and sports competition, the incidence of anterior cruciate ligament injury has increased significantly, but there are also studies showing that the incidence of anterior cruciate ligament injury in Chinese athletes is 0.39%. The main cause of anterior cruciate ligament rupture is sports injuries, accounting for more than 70%, and the most affected people are basketball and football. For the treatment of patients with ligament injuries, people have developed nanoartificial ligaments to reconstruct anterior cruciate ligaments and use the exercise effect of tennis to strengthen the repair of sports injuries.

The material of the nanoartificial ligament is polyethylene terephthalate (PET), which is the same as the material of surgical sutures and artificial blood vessels and has good biocompatibility. It can effectively share the gravity and be absorbed by the human body. It is safe to use and will not cause rejection. The nanoartificial ligament adopts the bionic structure design, and the two end structures are densely woven in the middle; there is loose free fiber in the middle, and the mechanical properties are good. In addition, the tennis exercise accelerates the repair of the patient's physical function, and the effect is more excellent [1, 2]. The safety and functional evaluation of the knee joint is an important part of the evaluation of the efficacy after ACL reconstruction. Currently, Lachman is used to evaluate the front and back stability of the knee joint, and the axial movement test is used to evaluate the rotation stability of the knee joint. Flexible stability is required in activities [3]. Modern three-dimensional walking analysis technology provides a new method for objectively, accurately, and quantitatively evaluating the stability and function of sports knee joints and is widely used to evaluate the efficacy after ACL reconstruction [4, 5].

1.2. Related Work. Seijas mentioned in his paper that an anterior cruciate ligament (ACL) injury is a highly injured accident in the working area of young athletes. The use of bone grafts, despite being a treatment option, can still cause postoperative problems, such as pain in the anterior knee, which limits its use and leads people to prefer alternative grafts. Their purpose was to evaluate whether the application of PRGF can reduce the pain of the anterior knee at the donor site reconstructed by BTB-ACL. The materials and methods they used are as follows: 55 patients participated in double-blind and randomized clinical trials, compared two groups of patients who used ACL transplantation for ACL reconstruction, and whether they used PRGF at the donor site after harvesting the graft. Knee pain results compared with the control group: the pain in the donor site of the PRGF group was reduced, and there was a significant difference in the first two months of follow-up [6]. Kim's research believes that various knee joint injuries caused by anterior cruciate ligament have been identified as important risk factors for the development of knee osteoarthritis (OA). However, no studies have been conducted using large sample studies to examine the relationship between ACL and OA. His research goal was to use the National Health Insurance Service Cohort data to study the impact of ACL injuries and other related knee joint structures on the development of OA. It also designed a retrospective cohort study of epidemiology and set up a database of epidemiological research service groups from the active adult population of the National Health Insurance [7]. Gomes' study believes that knee osteoarthritis (KOA) lacks sufficient treatment response outcome indicators. The role of ultrasound in the treatment of inflammatory joints and periarticular diseases has been well established, but its application in OA is less. The purpose is to develop a new high-resolution US protocol to assess the structure and inflammation of primary knee osteoarthritis. The scanning protocol was jointly developed by three high-level rheumatologists with similar experience in the United States. The proposed scheme has been shown to be reliable for patients with KOA and is therefore a promising tool that can be used for clinical practice and research purposes [8].

1.3. Innovation in This Article. The main innovative work of this paper includes the following aspects: (1) use modern three-dimensional gait analysis technology to evaluate the dynamic knee rotation stability and lower extremity function after ACL reconstruction with nanoartificial ligament and compare it with patients after autologous tendon transplantation. (2) The expression of PDGF and BMP-2 in the tendon-bone interface was measured by immunohistochemistry, which laid a certain foundation for further clarification of the vascularization of the tendon-bone interface and the specific bone formation mechanism. The research in this paper can provide a perfect and improved development suggestion for the rehabilitation training of patients with ligament injury and can also provide new ideas for the research in the field of medical rehabilitation.

2. Nanoligament Combined with Tennis Training Method for Rehabilitation Training

2.1. Nanoligament Based on ACL Reconstruction Technology. ACL reconstruction was performed in a supine position. Bone and joint endoscopy was performed after bleeding, and the knee joint cavity was regularly checked to confirm ACL injuries and other beds. At this time, first consider using nanoligaments to help patients deal with ligament injuries; first deal with combined injuries: the extent of half-moon cartilage injury, shaping, subtotal resection, total resection, or suture [9, 10]. According to the principles of isometric reconstruction surgery described in the literature, reassemble the ACL and regularly maintain the ACL gap. First, use special locators to create tunnels for the hard bones and thigh bones. The external connector of the cervical bone is approached through the inside of the front, the center of the opening of the Qinggu tunnel joint is 7 mm in front of the PCL, and the blind needle forms a cervical bone tunnel with a diameter of 6.5 mm through the ACL stump [11, 12]. Then, arrange the thigh bone external device through the hard bone tunnel. The center of the inner mouth of the thigh bone tunnel is located in the hepatology of the right knee. The liver and the lower edge of the posterior wall fall 6 mm. The position of the femur is generally determined by medical instruments. Drill the guide pin through the femur in reverse, penetrate the skin in front of and on the side of the thigh, make a 4 cm skin incision at the point of the femoral needle, use a series of cannulas to protect the soft tissue of the thigh, and drill from the lateral femur with a guide needle Through the femoral tunnel reaching the knee joint, the specific scheme is shown in Figure 1 [13, 14].

Once the bone tunnel is established, the nanoligaments will be installed and fixed. Select 150 bundles of fibrous LARS artificial nanoligaments (AC 120 2B) from the left or right knee [15]. Electric wires are introduced from the external opening of the thigh tunnel through the knee joint and connected through the hard bone tunnel. Place the LARS artificial ligament on the steel wire, and after the external port of the bony tunnel passes through the knee joint, the LARS artificial nanoligament will pass the ACL stump from bottom to top. The free fiber enters the thigh tunnel 1 mm, and the external ligament rotates slightly outward. Along the external opening of the thigh tunnel, connect the 8 mm diameter interface to squeeze the screw to fix the ligament. Attach a loop of artificial nanoligament at the end of the bone, bend or unfold the knee joint 30 times, adjust the ligament tension, confirm the knee joint mobility, spine angle projection, and confirm whether the LARS artificial nanoligament will affect the impact between the head and the posterior cruciate ligament (PCL) [16, 17]. In a 30- to 40-degree

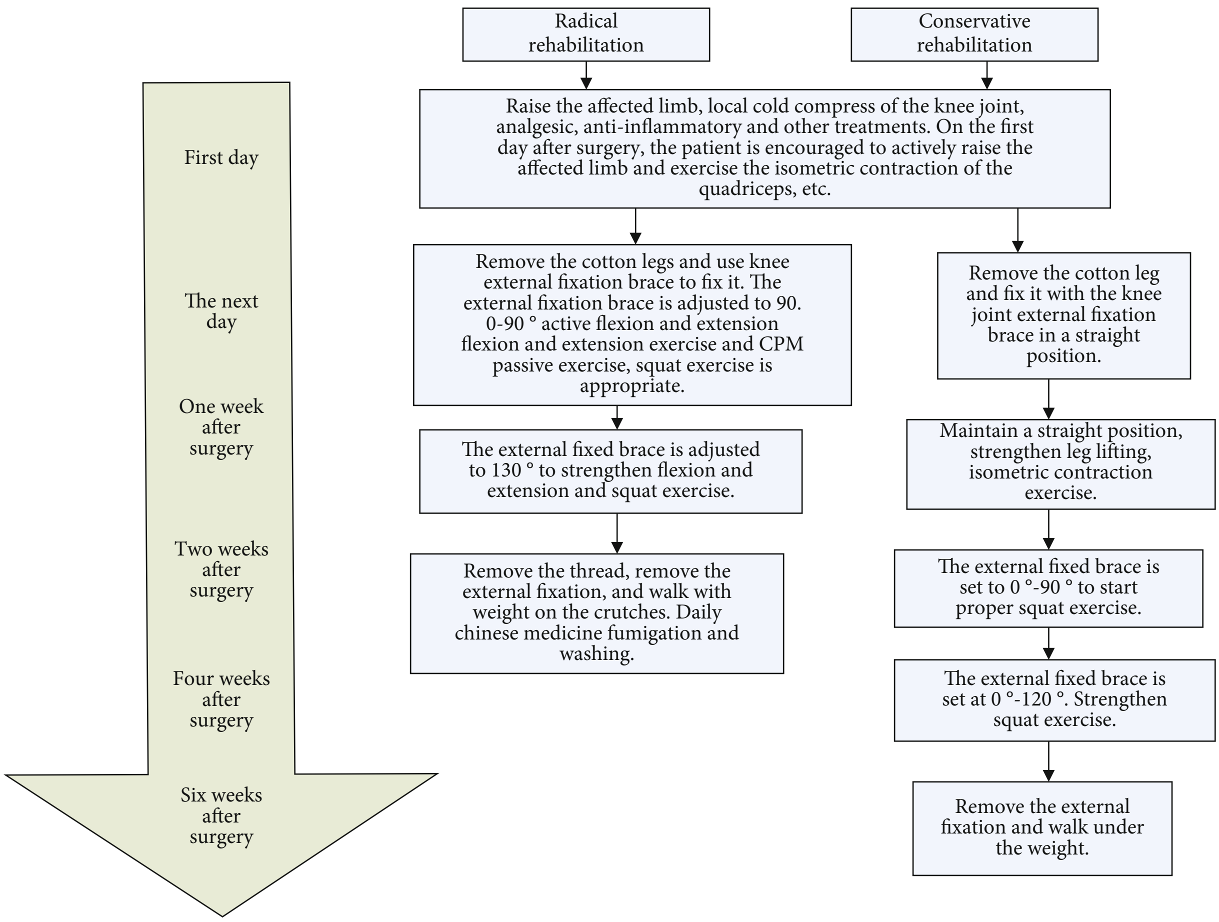

Figure 1: ACL reconstruction technique treatment plan.

bend of the knee, push the hard bone backwards and use three 15 mm diameter interfaces to braid the screw to fix the hard bone end of the ligament. Cut the extra ligament outside the femoral tunnel and the hard bone tunnel, and suture the incision [18, 19].

Use the same rehabilitation program in the four centers. No bracing is required after surgery. From the first day after the operation, the quadriceps muscle function training was started. Subsequent training programs and training volumes are determined according to the degree of recovery. The next day, the ground was partially weight-bearing. The knee ROM reached 0°-90° 1 week after the operation. Partial weight-bearing of abduction was 1-2 weeks after operation, and it gradually transitioned to complete weight-bearing at 4 weeks after operation. Daily activities resumed 6 weeks to 3 months after surgery, started jogging 4 months after surgery, and gradually resumed unrestricted exercise 3 to 6 months after surgery [20, 21].

After the operation, apply pressure to all patients, wrap the bandage in a correct position and fix it, raise the affected arms and legs, apply a local cold compress to the knee joints, relieve pain, and implement anti-inflammatory treatment. On the first day after surgery, it is best for patients to straighten the affected limbs and take active measures such as the sand head muscles [22, 23]. The cotton legs were removed the next day after rehabilitation removal surgery. The knee joints were fixed with external support frames. The external fixed struts had a range of motion of 0°-90° (0° full expansion). They adjusted the position and encouraged patients to go out [24]. Within the setting range of the fixed bracket, nonsupporting bearings activate bending and extend knee joints and continuous manual mechanical movement. Partial weight support can be used for squat exercise after one week of surgery. At this time, the patient's physical function has gradually recovered. Continue to observe for another week. At this time, the patient's physical function has gradually recovered. Continue to observe for another week, and the external fixed bracket is removed two weeks after surgery. Knee joint active flexion and renal motion indicate the supporting part of weight walking [25].

2.2. Structure of Knee Ligaments and Damage Mechanism. The medial structure of the knee ligament is divided into three layers from the surface layer to the myocardium. The medial ligament (MCL) and the medial joint capsule and their thick parts have the function of preventing excessive dryness of the knee joint. The lateral structure is divided into 3 layers, the first layer is the urethral tube branch and the posterior expansion of the arm, and the second layer is the anterior knee muscle membrane and the posterior part of the quadriceps and the two knee bands. The third layer is the half-moon ligament, lateral half-moon ligament, arcuate ligament, and joint capsule. The posterior structure is reinforced by the posterior structure formed by the wrist tendon and the forearm thigh and its accessory structure. It is separated from the joint capsule by the synovial capsule; the posterior part is healed with the joint capsule and the medial meniscus. The side structure mainly prevents excessive knee reversal, and the second role is to prevent excessive knee deformation and internal rotation. The anterior cruciate ligament and posterior cruciate ligament of the joint. The anterior cruciate ligament can be divided into the anterior medial, posterior and external junctions, and the anterior internal junction. In knee extension, the long axis of the attachment surface is nearly vertical. The cross section of the attachment end of the tibia is approximately triangular, with the base facing forward and the tip facing backward. The important function of this angle is to prevent forelimb bones, medial rotation, knees, and hyperextension. The posterior cruciate ligament can be divided into anterior posterior and posterior and posterior interior. The anterior and external are tense, the posterior and internal are slack, the posterior and internal are stretched when the knee is stretched, and the anterior and external are slack.

The most common electromechanical damage to the medial ligament is the direct violence on the side of the knee joint, which leads to knee trauma and damage to the medial ligament. Because the lower dead point of the medial ligament is wider, it is generally stopped at the thigh or joint space where the injury occurs near the ligament. If the violence is severe or the knee joint rotates and hurts in parallel, ligament rupture and joint dislocation may occur simultaneously. Lateral ligament injuries are mostly caused by direct violence against the medial knee, and the incidence is significantly lower than that of the medial ligament ligaments, and the posterior tendon is damaged by the hard bone mutation and lateral ligament injury. There are damaged ligaments and arcuate ligaments in the lateral structure. If the violence is large, the posterior structure of the knee joint will be damaged, and the cruciate ligaments can be merged. When walking or exercising, it will cause pain above the fibular head on the posterolateral side of the knee. In addition, the patient will also cause pain on the outside of the knee joint when the patient bends his legs or crosses his legs. The damaged mechanism of the anterior cruciate ligament often bends, and the lateral turn is injured, causing the medial ligament to be injured. There are also few trauma injuries, partial or complete fracture of the anterior cruciate ligament. Damage to the posterior cruciate ligament often occurs when the forearm is hardened; that is, the posterior cruciate ligament ruptures in front of the muscle bone. The posterior cruciate ligament is affected by femoral osteoporosis and the posterior cervical bone platform. The ligament may be injured when bending occurs. Excessive knee injury may cause posterior cruciate ligament injury.

2.3. Construction Method of Nanoligament Combined Fiber Composite Ligament. Since the mechanical properties of ligament materials made of regenerated silk fibroin materials cannot meet the requirements, the dense structure of ligament materials composed of natural silk fibroin fibers affects the adhesion and growth of cells. The above silk fibroin materials have their own performance defects, and we combine three methods to form artificial nanoligaments to form a regenerated silk fibroin nanoligament composed of silk fibroin fibers, silk fibrils, and natural silk fibrils. The main structural design of the regenerated silk fibroin fiber composite nanoligament still uses YTS2-24 vertical rotary polishing machine and core brake. It can demonstrate well the original basic structure of the regenerated silk fibroin nanoligament. The schematic diagram of fabric formation is shown in Figure 2 (picture from http://www.pixabay.com). During the construction process, silk fibers were first woven with cashmere, which greatly improved the shortcomings of the easily deformable tubular fabric. Second, the outer gauze is used to dye the fabric layer between natural silk fibrin fibers and cotton, and the outer gauze is used to make the fabric layer. After being controlled with an angle of $45 + 2^{\circ}$, the outer layer of the electrospun nanofiber membrane with a thickness of 3 mm is packaged. This fibrous membrane is one of the main ways to prepare nanofibrous materials, which can be effectively applied to the immobilization of enzyme catalysts. As a result, the broad fabric layer is woven with natural silk fibroin fibers from the packaging raw yarn. Finally, the composite structure of regenerated silk fibroin fiber composite nanoligaments is composed of electrospun nanofiber membranes and natural silk fibrous fiber fabrics.

Figure 2: Schematic diagram of nanoligament fabric formation.

According to the conclusion of the mechanical properties of the ligament material formed by different layers of natural silk fibroin fibers, if weaving 8 layers, the mechanical properties of the material are close to the human ACL, so during the formation of composite nanoligaments, the individual layer fiber weaving method is matched with two different silk fibroin fiber materials. In the hybrid project, the ratio of electrospun nanofiber membranes to natural silk fibroin is 1 : 1; that is, the number of fabric layers formed by natural silk fibroin fibers is 8 layers, while the electrospun nanofiber membranes have 7 layers. The silk fibroin filaments are woven into the middle of the nanoligament material as a shaft yarn. This ratio is mainly to unify the applicability and functionality of the nanoligaments.

3. Nanoligament Rehabilitation Training Experiment

3.1. Experimental Sample. The subjects of this experiment were 100 patients with different degrees of ligament injury. According to their prevalence, 50 patients underwent corresponding nanoligament surgery. In the subsequent rehabilitation training, data collection was carried out. First, tennis was added to 100 rehabilitation patients to assist in knee flexion. The experiment recorded the knee flexion test results of 50 nanoligament treatment and nontreatment patients. Later, different tennis techniques were used to record the recovery of patients with nanoligaments. Finally, do another set of comparative tests. Patients treated with nanoligaments were divided into three groups to test the knee flexion angle. The LARS group, the HT group, and the control group were 2.7 ± 1.3 degrees, 2.8 ± 2.5 degrees, and 2.1 ± 2.7 degrees, respectively. These different knee flexion angles represent different degrees of injury in rehabilitation patients, which are used as experimental variable data in this paper.

3.2. Experimental Environment Classification Setting. The degree of knee nanoligament damage can be divided into 3 degrees: first degree: ligament fiber rupture, local pain, no change in joint stability; second degree: most ligament fiber rupture, severe local reaction, function is obviously limited, but almost does not affect the stability of the joint; third degree: the ligament is completely damaged. According to the pressure test after ligament injury, the degree of the edge of the joint surface can be divided into mild (6 mm), intermediate (6-15 mm), and severe (greater than 15 mm). The treatment of first-degree and second-degree injuries requires conservative treatment. Patients with mildly injured ligament rupture and minor restlessness can also be treated conservatively. Conservative treatment is largely aimed at the patient population without severe impairment of joint stability. Four to 7 weeks of fixed plaster to strengthen the quadriceps movement can obtain satisfactory results. If the lateral ligament and surrounding tissue are severely damaged, unstable, or the cruciate ligament or meniscus is damaged, it should be repaired in time.

3.3. Experimental Procedure

(1) Experimental preparation: exclude patients with carotid artery injury and related fractures. The patient was placed in a supine position and underwent spinal canal anesthesia. In many cases of ligament injury, epidural block anesthesia is used. The inflatable tourniquet near the thigh was pressurized. Reconfirm the stability of the front, back, inside, outside, and rotation of the knee

(2) Experimental examination: arthroscopy device (arthroscopy equipment belongs to medical imaging equipment, mainly including American Stryker brand monitors, cold light sources, cameras, and image systems) and knee arthroscopy, standard surgical method for knee arthroscopy, anterior cruciate ligament reconstruction device. After stopping the blood, pressurize the tourniquet and check the blood in the joints. First, check the joint cavity, repair the damaged meniscus, perform suture, formation or resection, check the end and continuity of ACL and PCL, regularly clean, and explore under the microscope to maintain the stability of ACL and PCL. This is for the late replacement of blood circulation and blood circulation reconstruction of ligaments and the rapid recovery of inherent tolerance. Observe the medial and lateral articular walls of the hematoma under a microscope, observe the structural damage signals of the medial and lateral sides, and perform knee cartilage injury and classification

(3) Reconstruction of the posterior cruciate ligament: insert the PCL tibial catheter into the posterior tibia from the anterior medial aspect. In addition, it can also be placed under the observation of the posterior medial approach, and its front end is embedded in the exit of the tibial tunnel. Select the guide pin through the anterior cortex of the tibia (45- to 50-degree direction), select the appropriate diameter of the drill according to the size of the graft, to avoid nerve and blood vessel damage at the roost, and please pay attention to the tibia. The bones and soft tissues remaining in the tunnel are cleaned to avoid sharp parts. Similarly, a rocket tunnel of the same diameter was excavated using a femoral locator. After the tunnel is completed, the needle is inserted into the tibial tunnel from front to back, and the front end of the needle is slightly curved to facilitate the clamping of the intercondylar notch. Similarly, the femoral wire or microbridge stays ahead and follows the tibial tunnel to a single figure. The traction line of the head button is close to the traction line of the femur to connect the femur. The lead is pulled to rotate the built-in button, and the graft is retracted by 6 mm. The button is pressed parallel to the cortex of the femur at the external opening of the bone tract, and the tibial end of the graft is tightened, and the distal bone tract is fixed with absorbable nails larger than the same diameter

(4) Anterior cruciate ligament reconstruction: connect the tibial tunnel guide, position the top of the guide at the midpoint of the line between the anterior angle of the lateral meniscus and the medial condyle (a more accurate positioning method), and follow the locator drill into the guide pin and observe whether the position of the needle point is accurate under the microscope. Then, use the tibial drill bit to drill the tibial tunnel of the same diameter along the guide pin to clean the excess tissue of the tunnel. Then, use the femoral end guide to locate the ACL. At the top dead center, after the positioning is accurate, drill the guide pin along the positioner, use a 4.5 mm diameter hollow drill and the same implant diameter drill bit to drill the rocket-shaped tunnel, and the guide pin is pulled to place the pull wire.

Connect the graft traction line with the indwelling traction line in the knee flexion position, pull it out along the tibial tunnel, joint cavity, and femoral tunnel, flip the button so that the button is parallel to the femoral cortex embedded in the external opening of the bone tract, and tighten the end of the tibia. Fix the distal bone tract with absorbable nails larger than the same diameter. After the reconstruction is completed, the position relationship of the reconstructed ligament can be checked under the microscope again, and there is no intercondylar impact when the joint is moving

4. Analysis of Postoperative Rehabilitation of Patients Treated with Nanoligaments

4.1. Effect of Different Tennis Stretching Exercises on Patients after Nanoligament Surgery. In tennis, the functional traction of the body's flexibility mainly reflects the lateral flexion and expansion of the entire spine, so the lateral flexion and expansion of the body are indicators of testing the body's flexibility. Ligaments are distributed throughout the body, preventing bones from bending and expanding. The entire range of motion of the ligaments is very large and can be used for bending and elongation movements around the front axis. Nanoligaments treat patients with lateral flexion motions around the rotation axis and orbital motions and circular motions around the vertical axis. Generally, ligament activity is large, and rib activity is low. Ligaments are the key to maintaining joint movements of the body. The trunk is the core that connects the limbs and the head. The brain communicates commands to all parts of the body and controls the core connection of body movement. According to the biomechanics principles of tennis technical action, the center of gravity of the body should be kept stable during the strike, the body should not be shaken during the strike, and the quality of the strike should not be affected. The range of motion of the ligament should be maintained on a relatively fixed vertical axis.

As can be seen from Figure 3, after 8 weeks of training, the performance of each experimental group has been improved in the bending test of the side of the body of patients treated with nanoligaments, which is accelerated by nearly 5 times faster than that of general treated patients through static stretching exercises The sport effect is the most ideal. The static stretching exercise is to continuously and stably stimulate the stability of the ligament of the subject, thereby improving the structural function of skeletal muscles. With the deepening of the training phase, the static stretching exercise is more beneficial to the training effect of nanotreatment patients. Subjects can improve the level of flexible quality training in system management and increase the degree of lateral ligament curvature. In the process of stretching, the human lumbar spine does not have many muscle protection functions. It is necessary to pay attention to the muscles of the spine muscles in the lumbar spine, square muscles in the lumbar spine, and part of the erector spinae. The main function of the human waist and abdomen is not to simply improve the mobility of the joints, but to emphasize painless activities within the normal range of human motion, so pay attention not to damage the lumbar spine during the stretching exercise. No matter what kind of stretching method is used, you must avoid sneak attacks and oppressions. Pay attention to it in sections, increase

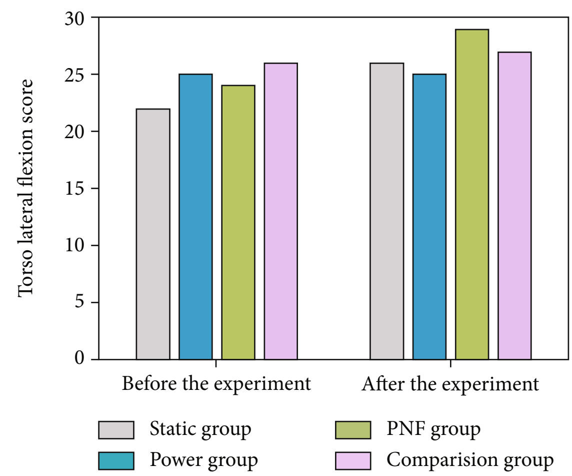

Figure 3: Comparison of the results of each group's lateral flexion test.

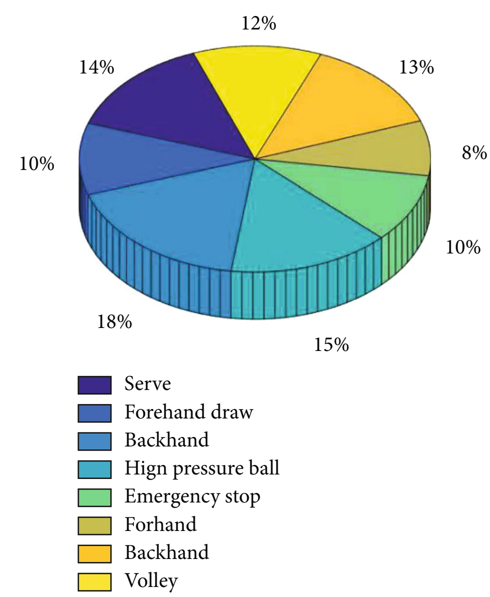

Figure 4: Table of the types of technical actions that affect the occurrence of knee ligament injury.

Table 1: Technical action factors affecting the occurrence of knee injury.

Serial number	Relevant factors	Load factor
1	Unfamiliar technical action	0.75
2	Technical moves are difficult	0.73
3	Technical action is very standard	0.24
4	Wrong technical action	0.78

Table 2: Knee flexion and extension and rotation angle.

Knee flexion and extension angle during standing	LARS group	HT group	Compare group	p value group
Heel	2.7 ± 1.3	2.8 ± 2.5	2.1 ± 2.7	0.457
Knee bending angle	31.2 ± 8.6	6.9 ± 3.5	31.5 ± 8.8	0.354
Knee flexion angle	7.1 ± 3.5	30.8 ± 4.7	6.8 ± 3.2	0.452
Maximum internal rotation	5.3 ± 1.4	5.2 ± 1.0	4.8 ± 1.5	0.321
Minimum internal rotation	7.2 ± 0.9	7.8 ± 1.3	5.2 ± 1.6	<0.002

the range of ligament movement in a slow and powerful way, and improve the body's ability to stretch the body of the tennis ligament patient while ensuring safety. And the breathing adjustment mentioned in the previous specific experimental program can make the stretching exercise get better results.

4.2. Analysis of Tennis Movement Technical Movements on Patients after Nanoligament Operation. As the key reason that affects whether a person's ligament is vulnerable to damage, technical action should be divided into various factors for analysis and research. Patients with different ages of nanoligament treatment should show their own type of technical action. The difference is very limited, and the analysis and research on the types and factors of technical actions should not be divided into different age groups.

The data in Figure 4 shows that the technical actions that caused the injury of the nanoligaments to treat patients were ranked as follows: 14% serve, 10% backhand ball, 18% forehand ball, 100% backhand ball fifteenth, 10% for emergency stop change, 8% for high pressure ball, 13% for forehand, and 12% for interception. For tennis players, every incorrect technical action may lead to damage to the knee ligaments. Among them, serving, backhand drawing, forehand drawing, and backhand cutting cause a high probability of knee injury. But at the same time, every standard action can avoid a knee injury. Therefore, the treatment of patients with nanoligaments can use standardized actions to accelerate the speed of recovery.

According to the sociological statistical methods and statistical principles, using SPSS 15.0 data analysis software, the load factor range of 16 causative factors is $0 < K < 1$; that is, the larger the K value, the more likely to have knee ligament injury, and the more Xiaoyue is conducive to the protection of the knee joint. Because the influence of each factor on the knee ligament injury is not absolute, it is impossible to have $K = 0$ or $K = 1$. The specific load factor is shown in Table 1.

Analysis of the data in Table 1 shows that the technical action factors greatly affect whether the rehabilitation of patients with ligament injury can be accelerated. This requires that the technical movements mastered by the patients in training must conform to the characteristics of tennis and at the same time meet the requirements of physiological anatomy or try to comply with the principles of biomechanics. Effective and correct technical actions are conducive to the full play of athletes' physiology and psychology and help nanoligament treatment patients to achieve good rehabilitation results.

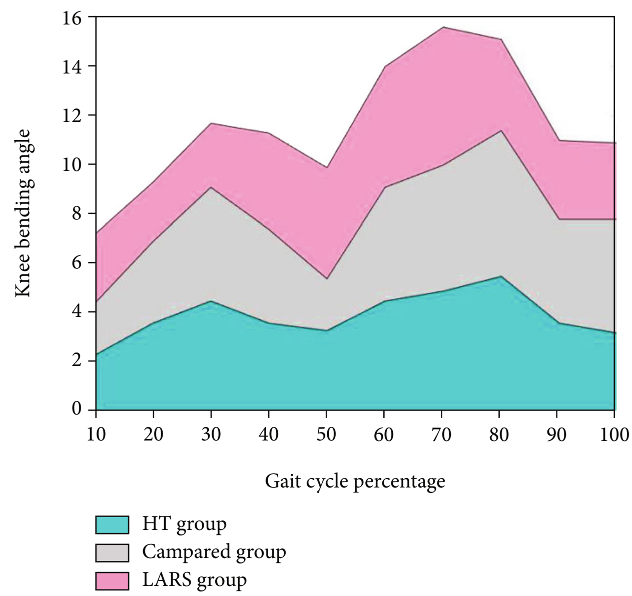

Figure 5: Knee flexion and extension angle when walking.

4.3. Analysis of Knee Flexion Angle after Nanoligament Treatment. Using one-way analysis of variance (ANONA), the time-distance parameters, knee internal rotation, external rotation angle, knee flexion, knee extension angle, and sagittal plane vertical reaction of the LARS group and the HT group affected lower limbs and normal control force comparison. SPSS 12.0 software was used for all statistical analysis. The significance level is $a < 0.04$. Sagittal knee angle during stance: the knee flexion angle when the heel is on the ground is 2.7 ± 1.3 degrees, 2.8 ± 2.5 degrees, and 2.1 ± 2.7 degrees in the LARS group, the HT group, and the control group, respectively. There was no difference between the three groups (statistical significance $p > 0.04$). The maximum knee flexion angle and the minimum knee flexion angle in the standing period are 31.2 ± 8.6 degrees and 6.9 ± 3.5 degrees, 31.5 ± 8.8 degrees and 7.1 ± 3.5 degrees, and 30.8 ± 4.7 degrees and 6.8 ± 3.2 degrees in the LARS group, the HT group, and the control group, respectively. Compared with the three groups, the difference was not statistically significant ($p > 0.05$), as shown in Table 2 and Figure 5.

The knee rotation angle of patients with nanoligaments during walking is shown in Table 2 and Figure 6. The maximum internal rotation angle was 5.3 ± 1.4 degrees, 5.2 ± 1.0 degrees, and 4.8 ± 1.5 in the LARS group, the HT group, and

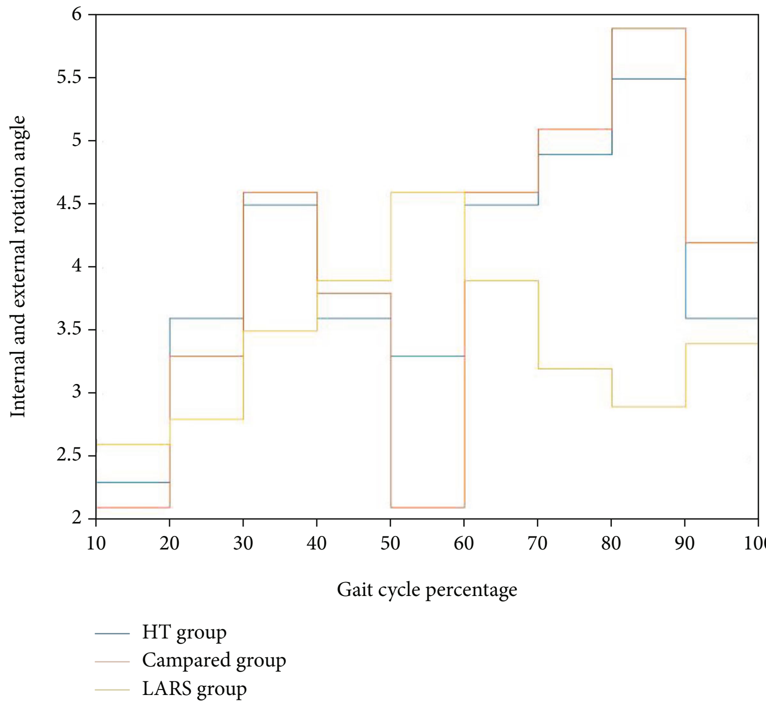

Figure 6: Knee rotation angle when walking.

the control group, respectively. There was no statistically significant difference between the three groups ($p > 0.04$). The maximum external rotation angle of the knee joint was 7.8 ± 1.1 degrees, 8.2 ± 1.4 degrees, and 5.6 ± 1.9 degrees in the LARS group, the HT group, and the control group, respectively. The HT group and the LARS group were significantly larger than the control group ($p < 0.002$). There was no significant difference between the HT group and the LARS group ($p > 0.04$). Based on the above data and image analysis, nanoligament injury patients undergo tennis training and technical movement analysis after surgery, and a certain knee bending angle will also affect the rehabilitation effect of nanoligament treatment patients. Within a reasonable range, the corresponding rehabilitation training will speed up.

5. Conclusions

This research is aimed at the current clinical application of nanoligaments and the research of tennis sports on rehabilitation patients with sports injuries and the surface modification of nanoligament materials to improve their biocompatibility. And because of their small size, nanomaterials are very different from traditional materials in terms of optical properties, electrical properties, and chemical activity. The special properties of nanomaterials make it have full play in ECL sensing; in particular, some emerging nanomaterials are paid attention by researchers due to their superior performance and are widely used in ECL. Some inspirations can be obtained from this, which helps to clarify the future research direction of artificial ligaments.

This study further confirmed that from the biomechanical point of view, the combination of nanoligaments and tennis can promote the healing of the tendon and bone boundary surface after surgery. In order to avoid reconstruction failure caused by ACL slack, theoretical support is provided. The results of this experiment also show that the synthesized nanomaterials can act as a scaffold in the body, allowing PRP to slowly and fully release growth factors, gradually absorbed by new bone growth, and finally replaced by new bone, which is a more suitable scaffold.

In this study, at the early stage after surgery, the interface with a strength similar to the rest point is directly reduced. For the buffering of the stop stress, the mechanical characteristics of this rest point structure are better than the indirect rest point, and the bonding force of the tendon-bone interface is improved. This provides us with a new way of thinking, that is, after ACL transplantation, early recovery of work and exercise ability, to avoid failure of reconstruction caused by ACL relaxation and to promote functional rehabilitation in clinical practice. This experiment has only been studied in morphology, and the more direct evidence is that it needs the support of biomechanical experiments. Although this paper has carried out a profound study on the rehabilitation training of patients with ligament injury by using nanoligament combined with tennis exercise therapy, there are still many deficiencies. We will study appropriate treatment methods and means from more perspectives based on the existing technology and level and continuously improve the quality of rehabilitation treatment.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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References

[1] I. Singh and R. Narasimhan, "Notch sensitivity in nanoscale metallic glass specimens: insights from continuum simulations," *Journal of the Mechanics and Physics of Solids*, vol. 86, pp. 53–69, 2016.

[2] R. M. A. Domingues, S. Chiera, P. Gershovich, A. Motta, R. L. Reis, and M. E. Gomes, "Enhancing the biomechanical performance of anisotropic nanofibrous scaffolds in tendon tissue engineering: reinforcement with cellulose nanocrystals," *Advanced Healthcare Materials*, vol. 5, no. 11, pp. 1364–1375, 2016.

[3] S. E. Smith, R. A. White, D. A. Grant, and S. A. Grant, "Gold and hydroxyapatite nano-composite scaffolds for anterior cruciate ligament reconstruction: in vitro characterization," *Journal of Nanoscience & Nanotechnology*, vol. 16, no. 1, pp. 1160–1169, 2016.

[4] H. Yang, Z. Wang, C. Li, and C. Xu, "Nanoporous PdCu alloy as an excellent electrochemical sensor for H_2O_2 and glucose detection," *Journal of Colloid & Interface Science*, vol. 491, pp. 321–328, 2017.

[5] Y. Yang and W. Tang, "Elastic modulus determination at different levels of periodontal ligament in nanoindentation," *Journal of Southeast University*, vol. 33, no. 1, pp. 33–38, 2017.

[6] R. Seijas, X. Cuscó, A. Sallent, I. Serra, O. Ares, and R. Cugat, "Pain in donor site after BTB-ACL reconstruction with PRGF: a randomized trial," *Archives of Orthopaedic & Trauma Surgery*, vol. 136, no. 6, pp. 829–835, 2016.

[7] S. G. Kim, S. Y. Lee, Y. H. Lee, and S. Y. Lee, "The epidemiological study of post-traumatic knee osteoarthritis after knee ligament or meniscus injuries using national health insurance service (nhis) 514, 866 cohort data: retrospective cohort study," *British Journal of Sports Medicine*, vol. 51, no. 4, pp. 342.2–34342, 2017.

[8] J. L. Gomes, A. Sepriano, S. Falcao et al., "AB0954?A new ultrasonography protocol for the assessment of primary knee osteoarthritis," *Annals of the Rheumatic Diseases*, vol. 75, Supplement 2, pp. 1227.3–121228, 2016.

[9] N.-Y. Han, J.-Y. Hong, J.-M. Park et al., "Label-free quantitative proteomic analysis of human periodontal ligament stem cells by high-resolution mass spectrometry," *Journal of Periodontal Research*, vol. 54, no. 1, pp. 53–62, 2019.

[10] B. Alonso, F. B. Sobrón, C. Vidal, and J. Vaquero, "Pretibial pseudocyst after anterior cruciate ligament reconstruction with a biocomposite screw," *Acta Ortopédica Mexicana*, vol. 30, no. 3, pp. 150–153, 2016.

[11] M. Papandreou, E. Billis, G. Georgoudis, G. Papathanasiou, and J. Gliatis, "Ultrasonography study: supraspinatus muscle thickness evaluation on dominant versus non dominant shoulder on tennis players," *Journal of Exercise, Sports & Orthopedics*, vol. 3, no. 1, pp. 1–5, 2016.

[12] E. Bolach, B. Bolach, and K. Seniuk, "Analysis of training loads in the introductory micro-cycle during the phase of specific preparation of wheelchair tennis players," *Nephron Clinical Practice*, vol. 21, no. 3, pp. 36–49, 2013.

[13] G. D. Shifflett, D. W. Green, R. F. Widmann, and R. G. Marx, "Growth arrest following ACL reconstruction with hamstring autograft in skeletally immature patients: a review of 4 cases," *Journal of Pediatric Orthopaedics*, vol. 36, no. 4, pp. 355–361, 2016.

[14] A. Grassi, C. L. Ardern, G. M. Marcheggiani Muccioli, M. P. Neri, M. Marcacci, and S. Zaffagnini, "Does revision ACL reconstruction measure up to primary surgery? A meta-analysis comparing patient-reported and clinician-reported outcomes, and radiographic results," *British Journal of Sports Medicine*, vol. 50, no. 12, pp. 716–724, 2016.

[15] B. T. Samuelsen, K. E. Webster, N. R. Johnson, T. E. Hewett, and A. J. Krych, "Hamstring autograft versus patellar tendon autograft for ACL reconstruction: is there a difference in graft failure rate? A meta-analysis of 47, 613 patients," *Clinical Orthopaedics & Related Research*, vol. 475, no. 10, pp. 2459–2468, 2017.

[16] I. D. Smith, A. Irfan, J. S. Huntley, and S. J. Spencer, "What is the best treatment for a child with an acute tear of the anterior cruciate ligament?," *Journal of Paediatrics and Child Health*, vol. 54, no. 9, pp. 1037–1041, 2018.

[17] P. B. Kumar and D. R. Parhi, "Vibrational characterization of a human femur bone and its significance in the designing of artificial implants," *Military Operations Research*, vol. 14, no. 3, pp. 222–226, 2017.

[18] R. Mannem, M. Dubois, M. Koeberl, D. Kosempa, and S. Erickson, "Glenoid avulsion of the glenohumeral ligament (GAGL): a case report and review of the anatomy," *Skeletal Radiology*, vol. 45, no. 10, pp. 1443–1448, 2016.

[19] E. Santana and A. Portela, "Dual boundary element analysis of fatigue crack growth, interaction and linkup," *Engineering Analysis with Boundary Elements*, vol. 64, pp. 176–195, 2016.

[20] R. M. Palmieri-Smith, K. L. Cameron, L. J. DiStefano et al., "The role of athletic trainers in preventing and managing post-traumatic osteoarthritis in physically active populations: a consensus statement of the Athletic Trainers' Osteoarthritis Consortiuma," *Journal of Athletic Training*, vol. 52, no. 6, pp. 610–623, 2017.

[21] L. L. Laslett, J. P. Pelletier, F. M. Cicuttini, G. Jones, and J. Martel-Pelletier, "Measuring disease progression in osteoarthritis," *Current Treatment Options in Rheumatology*, vol. 2, no. 2, pp. 97–110, 2016.

[22] N. Fischer, N. M. Mathonia, G. Hoellerich et al., "Surviving murine experimental sepsis affects the function and morphology of the inner ear," *Biology Open*, vol. 6, no. 6, pp. 732–740, 2017.

[23] P. S. Thayer, S. S. Verbridge, L. A. Dahlgren, S. Kakar, S. A. Guelcher, and A. S. Goldstein, "Fiber/collagen composites for ligament tissue engineering: influence of elastic moduli of sparse aligned fibers on mesenchymal stem cells," *Journal of Biomedical Materials Research Part A*, vol. 104, no. 8, pp. 1894–1901, 2016.

[24] C. Gonzalez-Lluch, P. J. Rodriguez-Cervantes, L. Forner, and A. Barjau, "Inclusion of the periodontal ligament in studies on the biomechanical behavior of fiber post-retained restorations: an in vitro study and three-dimensional finite element analysis," *Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine*, vol. 230, no. 3, pp. 230–238, 2016.

[25] A. Houben, J. Van Hoorick, J. Van Erps, H. Thienpont, S. Van Vlierberghe, and P. Dubruel, "Indirect rapid prototyping: opening up unprecedented opportunities in scaffold design and applications," *Annals of Biomedical Engineering*, vol. 45, no. 1, pp. 58–83, 2017.